



**Procedures for Approval and Use of  
Instrument Augmentation Systems for  
Beef Carcass Ribeye Measurement  
Livestock and Seed Program, Agricultural Marketing Service**

February 2001

**BACKGROUND:**

The Department of Agriculture (USDA), Agricultural Marketing Service (AMS), Livestock and Seed (LS) Program will accept ribeye area measurements made by approved instruments to augment evaluations made by USDA graders in the application of USDA Yield Grades for beef carcasses. To be approved by the LS Program to use an instrument for such a purpose, the instrument must meet certain performance requirements for accuracy and repeatability in the determination of the ribeye area of carcasses. The performance requirements outlined in this document were established by an Industry Working Group that was convened by the LS Program and the National Cattlemen's Beef Association (NCBA) following a September 2000 meeting of beef production, beef packing, academia, and other interested parties. The Industry Working Group was comprised of representatives of USDA, NCBA, packing companies, an instrument manufacturer, and academia.

The purpose of this document is to provide the meat industry with a blueprint for developing the documentation that is required to gain instrument approval from the LS Program. The process consists of three phases:

- Phase I      Demonstration of the accuracy of an instrument based on measurements obtained from stationary beef carcasses.
- Phase II      Demonstration of the ability of an instrument to repeatedly meet performance standards while measuring images "on-line" at line speeds.
- Phase III      Daily in-plant verification of the approved instrument to validate that the instrument is correctly calibrated and that the correct data is presented to the USDA grader.

**PERFORMANCE REQUIREMENTS:**

In order to validate the accuracy and repeatability of an instrument, an *actual mean ribeye area* must be established for each carcass that is measured. Two methods have been approved by the Working Group to determine the *actual mean ribeye area*:

- Expert Mean Gridded Ribeye Area: Three experts experienced in measuring ribeyes will individually grid the ribeye of each carcass with

the official USDA ribeye grid. A mean value will be determined from the three individual measurements and will be reported as the *Expert Mean Gridded Ribeye Value*.

- Mean Acetate Traced Ribeye Area: Three qualified individuals will each independently trace the ribeye of each carcass. Each of the tracings will then be measured three times with a compensating polar planimeter to establish the *Mean Acetate Traced Ribeye Area Value*.

#### Phase I: Stationary measurement

One of two acceptable methods may be used for collecting images (data) from stationary carcasses for phase I. However, for either method, 200 sides shall each be measured three (3) times to provide a total of 600 observations to measure performance. The two methods are:

- Triple Trigger: Properly place the camera head unit (with as much precision as possible) over the 12<sup>th</sup>/13<sup>th</sup> rib interface of one side of each carcass, and obtain three sequential but separate images without moving the camera head unit.
- Placement method: Place the camera head unit (with as much precision as possible) over the 12<sup>th</sup>/13<sup>th</sup> rib interface on the side of the carcass to be measured and obtain one image; remove the camera head unit; return the camera head unit to the ribeye interface and obtain a second image; remove the camera head unit again; return the camera head unit to the ribeye interface, and obtain a third image. The system must be demonstrated to work equally effectively on both left and right sides. (It is suggested that one-half of the 600 images be determined on left sides and one-half on right sides.)

Performance requirements for Phase I (see Appendix):

Stationary Accuracy                       $R^2 = 0.95$  or greater;  $\pm 0.5$  sq. inches 95% of the time.

Stationary Repeatability                Ribeye areas must be within  $\pm 0.5$  sq. inches of the average of the individual estimates 95% of the time.

#### Phase II: Operational measurements

- Carcasses must be circulated in a continuous motion (at chain speeds in excess of 350 hd/hr) past the grading stand. As the carcasses are transported past the instrument during each circuit, the camera head unit of the instrument shall be placed over the 12<sup>th</sup>/13<sup>th</sup> rib interface of one side to collect one image (for a total of 200 sides x 3 replicates per side = 600 total observations (images)). For this

procedure, images should be obtained from both right and left sides to demonstrate the feasibility of collecting images from either side.

Performance requirements for Phase II (see Appendix):

Operational Accuracy       $R^2 = 0.90$  or greater;  $\pm 0.5$  sq. inches, 90% of the time.

### Phase III: Operational Process Verification

Procedures for verification of operational accuracy of instruments will be established on a "plant by plant" or "company by company" basis by the applicant and approved by the LS Program. An approved, verifiable process must be in place for a plant to use the instrument for ribeye area determination. Criteria that must be addressed in the Operational Process Verification Program include:

- Instrument set-up and calibration routine.
- Verification of system calibration before instrument use.
- Record of validations.
- Training/control of instrument operators.
- Operator audits.
- Linking of hot carcass weight, carcass image data, and presentation to grader.
- Grade identification/application procedures.
- Submission and approval of any system changes

LS may change the performance approval criteria when technology improves.

ADDRESS:

Requests for approval shall be submitted to:

Chief, Standardization Branch  
USDA, AMS, LS  
Room 2603 South Building, Stop 0254  
1400 Independence Avenue, S.W.  
Washington, DC 20250-0254

Phone: (202)-720-4486  
FAX: (202)-720-1112

Approved:

  
Herbert C. Abraham, Chief  
Standardization Branch

APPENDIX

Recommended Statistical Analysis

The simple average (mathematical mean) of the three independent grid measurements of the ribeye area of a carcass obtained by experts or the average of the three independent acetate tracings (and subsequent measurement with a compensating polar planimeter) will be defined as the "Actual Mean Ribeye Area." "Accuracy" of an instrument's estimate of the ribeye area for a given carcass will be assessed by comparing each instrument's estimate to the appropriate "actual mean ribeye area" measurement for each carcass and determining the strength of the relationships by use of correlation/regression analyses (Table 1). "Repeatability" of instrument estimates of ribeye area for stationary carcasses will be assessed by determining the mean absolute difference ( $\pm$  one standard deviation) from the average of the three ribeye area estimates obtained during the collection of each of the procedures tested in the study (Table 2). These repeatability estimates will be contrasted with repeatability estimates determined by comparable analyses among estimates of the three experts that have measured ribeye area using the plastic grid method. In addition, instrument repeatability may be compared to the results of acetate tracing and subsequent measurement with a compensating polar planimeter.

Table 1. Global coefficients of determination ( $R^2$ ) and RSD values for the overall mean expert gridded REA for all circulations, the overall mean acetate planimeter REA for each carcass side, and the overall mean Video Image Analysis (VIA) REA measurements (for two systems combined) by procedure.

Measurement Method	Mean VIA Ribeye Area Measurements					
	Triple Trigger <sup>a</sup> (Mean of 600 images)		Placement <sup>b</sup> (Mean of 600 images)		On-Line <sup>c</sup> (Mean of 600 images)	
	$R^2$	RSD	$R^2$	RSD	$R^2$	RSD
Mean Expert Gridded REA <sup>d</sup>	0.97	0.13	0.97	0.13	0.96	0.12
Mean Acetate Traced REA <sup>e</sup>	0.98	0.15	0.98	0.11	0.97	0.08

<sup>a</sup>Triple Trigger: Average of three sequential images of the 12<sup>th</sup>/13<sup>th</sup> rib interface by two VIA cameras = 6 total VIA readings/ribeye, without moving the camera head unit between images.

<sup>b</sup>Placement: Average of three images of the 12<sup>th</sup>/13<sup>th</sup> rib interface by two VIA cameras = 6 total VIA readings/ribeye, removing the camera head unit and replacing it between images.

<sup>c</sup>On-Line: Average of three images of the 12<sup>th</sup>/13<sup>th</sup> rib interface by two VIA cameras = 6 total VIA readings/ribeye, at commercial chain speeds (360 head/hr).

<sup>d</sup>Mean Expert Gridded REA: Average of three grid measurements by three expert graders per ribeye = 9 total grid measurements/ribeye.

<sup>e</sup>Mean acetate traced REA: Average of three tracings by three planimeter readings per tracing = 9 total planimeter readings/ribeye.

All correlations differ from zero ( $P < .0001$ ).

Table 2. Repeatability: Mean absolute difference and standard deviation values for the mean gridded REA measurements by circulation (N = 300), the overall mean acetate planimeter REA readings (N = 900), and the mean triple-trigger, placement, and on-line VIA REA measurements by procedures 1, 2 and 3 (N = 600).

Measurement Method	Mean Absolute Difference <sup>a</sup>	SD
Circulation 1 Expert grid REA <sup>b</sup>	0.22	0.23
Circulation 2 Expert grid REA	0.18	0.13
Circulation 3 Expert grid REA	0.19	0.17
Overall Expert grid REA <sup>c</sup>	0.20	0.19
Overall Tracing REA <sup>d</sup>	0.19	0.33
<b>Procedure 1:</b>		
Camera 1 Triple Trigger <sup>e</sup>	0.06	0.10
Camera 2 Triple Trigger	0.09	0.14
Overall Triple Trigger	0.08	0.12
<b>Procedure 2:</b>		
Camera 1 Placement <sup>f</sup>	0.14	0.20
Camera 2 Placement	0.12	0.13
Overall Placement	0.13	0.17
<b>Procedure 3:</b>		
Camera 1 On-Line <sup>g</sup>	0.21	0.21
Camera 2 On-Line	0.38	0.40
Overall On-Line	0.29	0.33

<sup>a</sup>Mean Absolute Difference: absolute difference of individual measurements from the average of those same measurements.

<sup>b</sup>Circulation 1 Expert grid REA: Average of three grid measurements per ribeye by three expert graders for circulation 1 (N = 300).

<sup>c</sup>Overall Expert grid REA: Average of three grid measurements per ribeye by three expert graders for all circulations (N = 900).

<sup>d</sup>Overall Tracing REA: Average of three planimeter readings per ribeye by three tracers (N = 900).

<sup>e</sup>Camera 1 Triple Trigger: Average of three sequential images per ribeye, of the 12<sup>th</sup>/13<sup>th</sup> rib interface by camera 1, without moving the camera head unit between pictures during procedure 1.

<sup>f</sup>Camera 1 Placement: Average of three images per ribeye, of the 12<sup>th</sup>/13<sup>th</sup> rib interface by camera 1, removing the camera head unit between images.

<sup>g</sup>Camera 1 On-Line: Average of three images per ribeye, of the 12<sup>th</sup>/13<sup>th</sup> rib interface by camera 1, at commercial chain speeds (360 head/hr).